Upper Mississippi River System Flow Frequency Study

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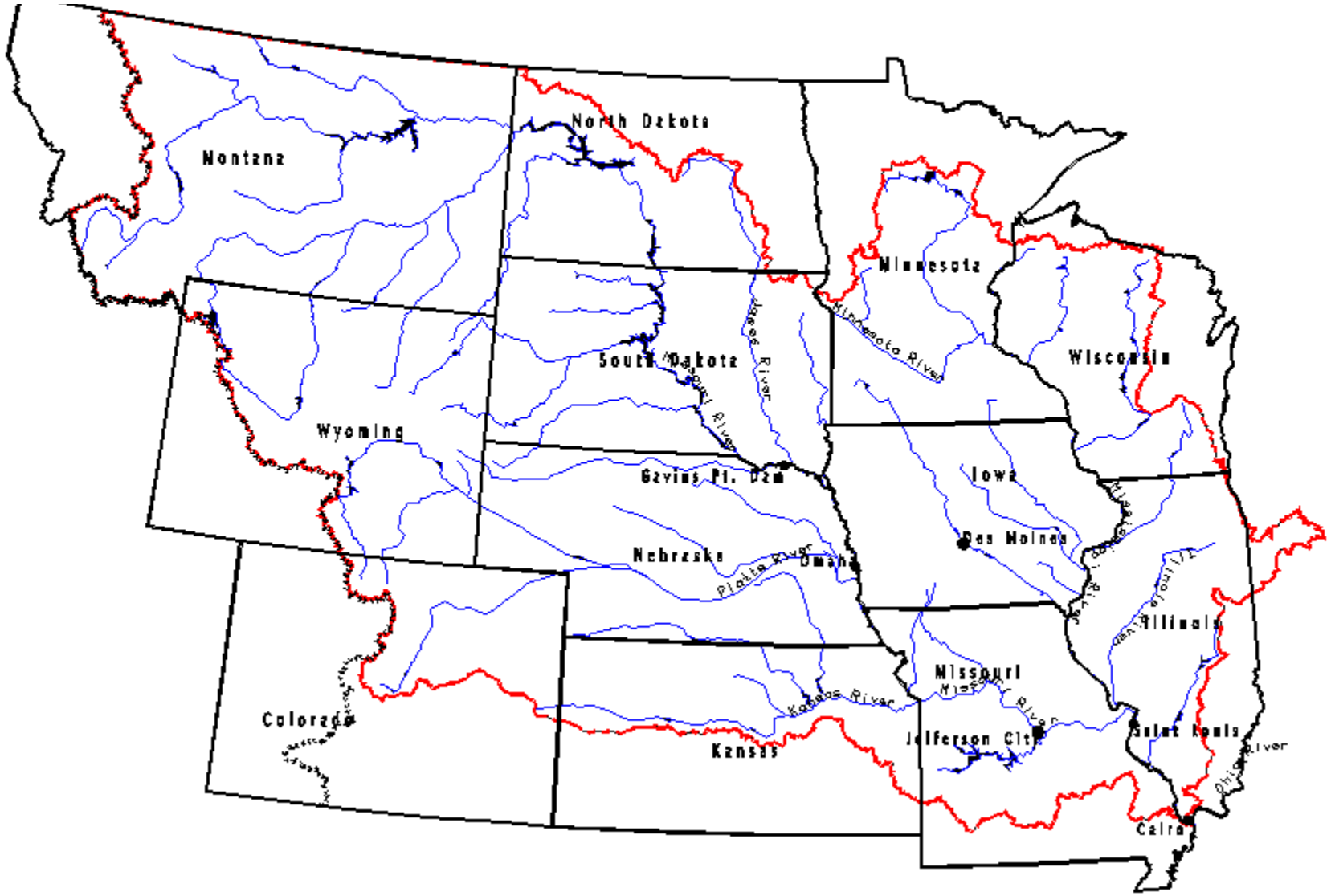
Outline

- Background
- Projections of future climate
- Trends in hydrologic record
- Alternative statistical models that do not assume “stationarity”
- Results – 1% flood estimates
- Data Quality Act petition
- Conclusion

Background

- Update the discharge frequency relationships and water surface profiles on Upper Mississippi River, Illinois River, and Missouri River below Gavins Point dam.
- After 1993 Mississippi River flood, communities were questioning their flood risk.

Study Area


Montana
North Dakota
Minnesota
Wisconsin
South Dakota
Wyoming
Gavins Pt. Dam
Nebraska
Omaha
Iowa
Des Moines
Illinois
Missouri
Kansas
Colorado
Jefferson City
Saint Louis
Cairo

New Methods

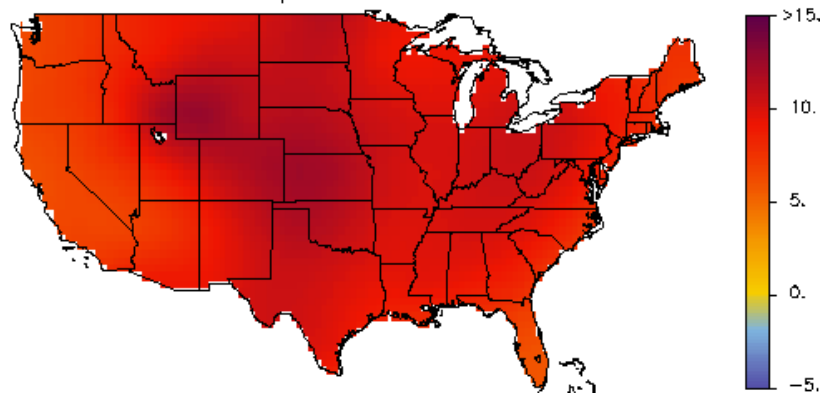
- Used unregulated flows at gages for flood frequency distribution.
- Flood control reservoir project impacts defined by developing regulated versus non-regulated relationships for discharges.
- UNET unsteady flow program used to address hydraulic impacts including levee performance.
- Considered effects of climate change and variability.

Projections of Future Climate

Projected Future Temperature

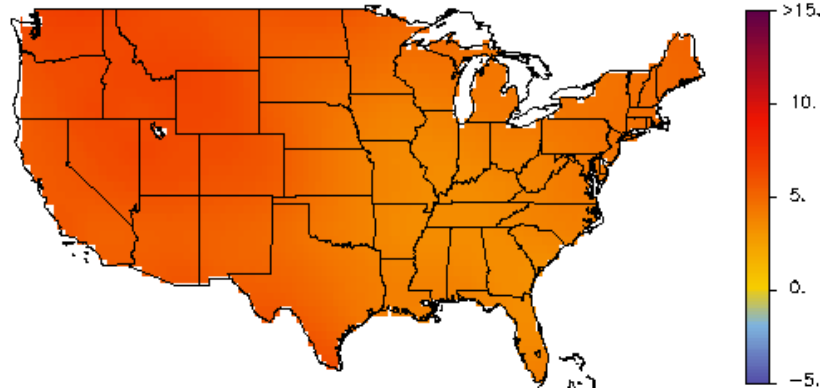
Canadian 21st Century

Annual Mean Temperature Trend

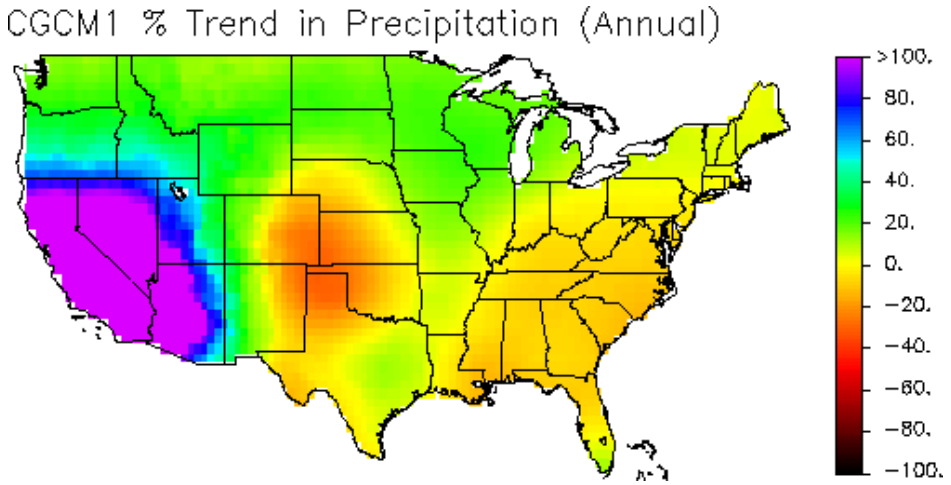


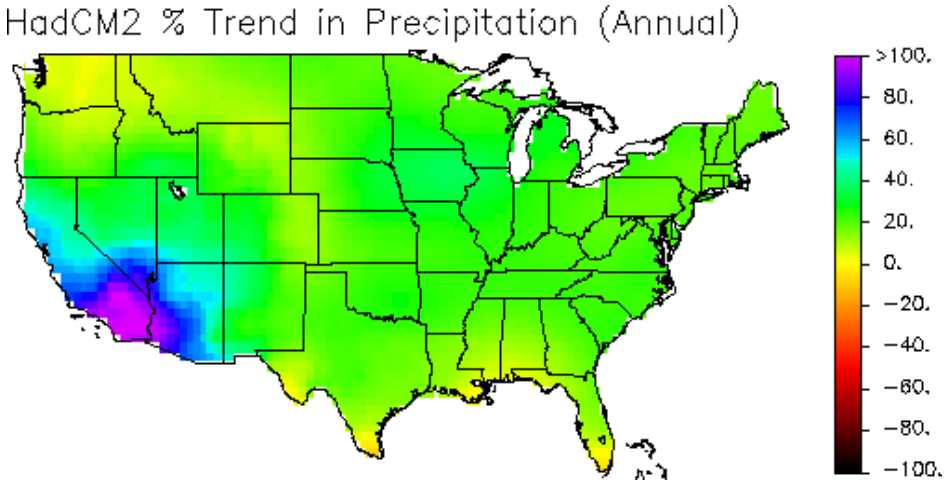
Hadley 21st Century

Annual Mean Temperature Trend



Projected Future Precipitation





Changes in Runoff based on GCM Simulations

- Runoff estimated using simple mass-balance model and temperature and precipitation from GCMs
- General Circulation Models (GCMs) do not agree on whether annual runoff will increase or decrease

Estimated Runoff and Changes (mm)

Region	Historical	Canadian	Hadley
	1961-1990	2025-2034	2025-2034
Upper Mississippi	195	- 42	42
Missouri	40	- 9	7

Conclusions: Future Climate

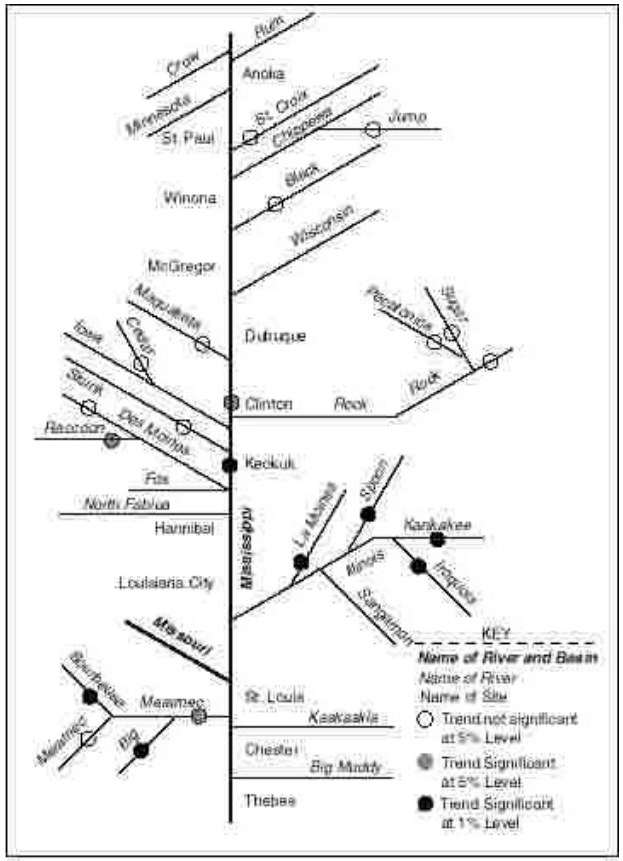
- Results of General Circulation Models used to project future climate are still ambiguous.
- Although flood magnitudes and frequencies may change as a result of global warming, evidence is not strong enough to project even the direction of change for the Upper Mississippi and Missouri River basins.

Trends in Hydrologic Record

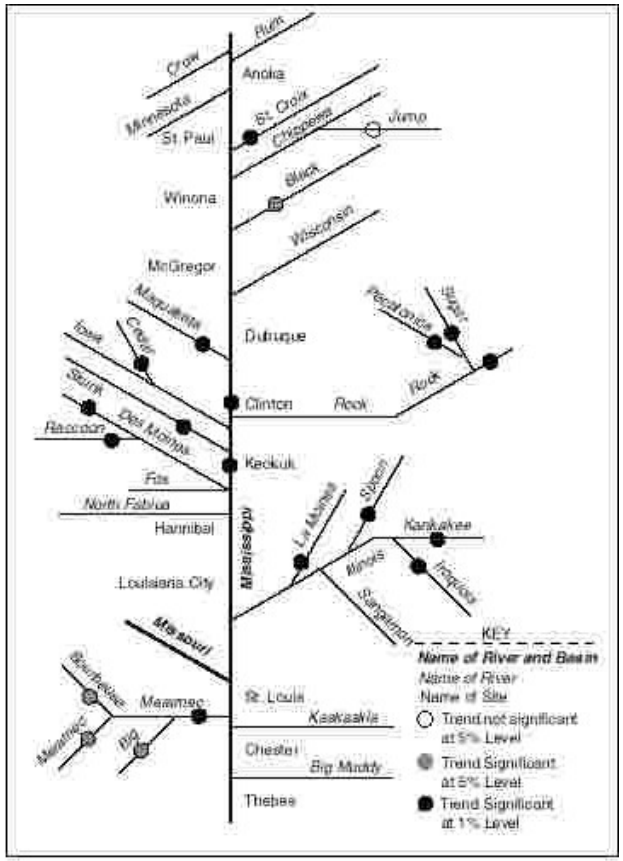
Conclusions: Trends

- Evidence of increasing temperature and precipitation in the region.
- Evidence flood risk may have changed over time for some stations in basin.

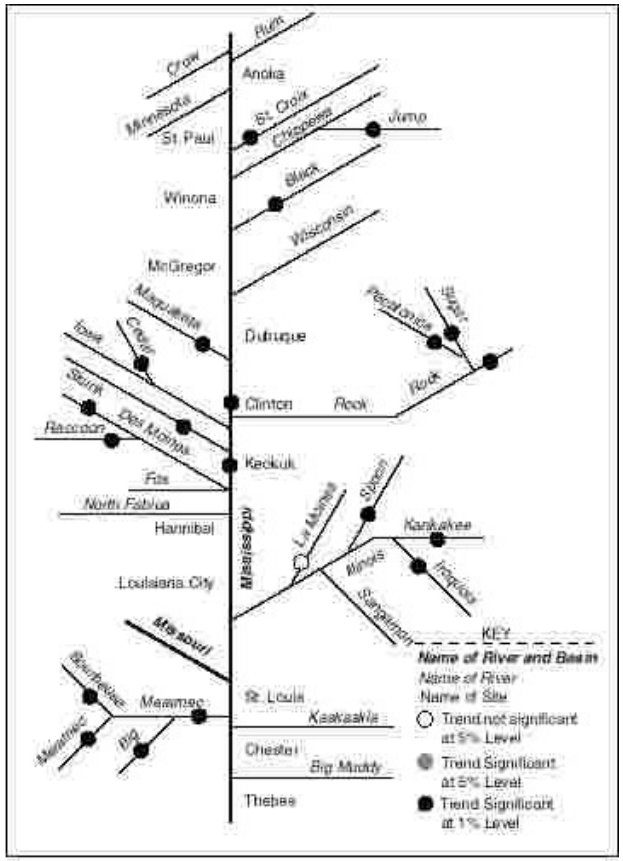
Upper Mississippi Trends



Annual Flood (1-Day High)

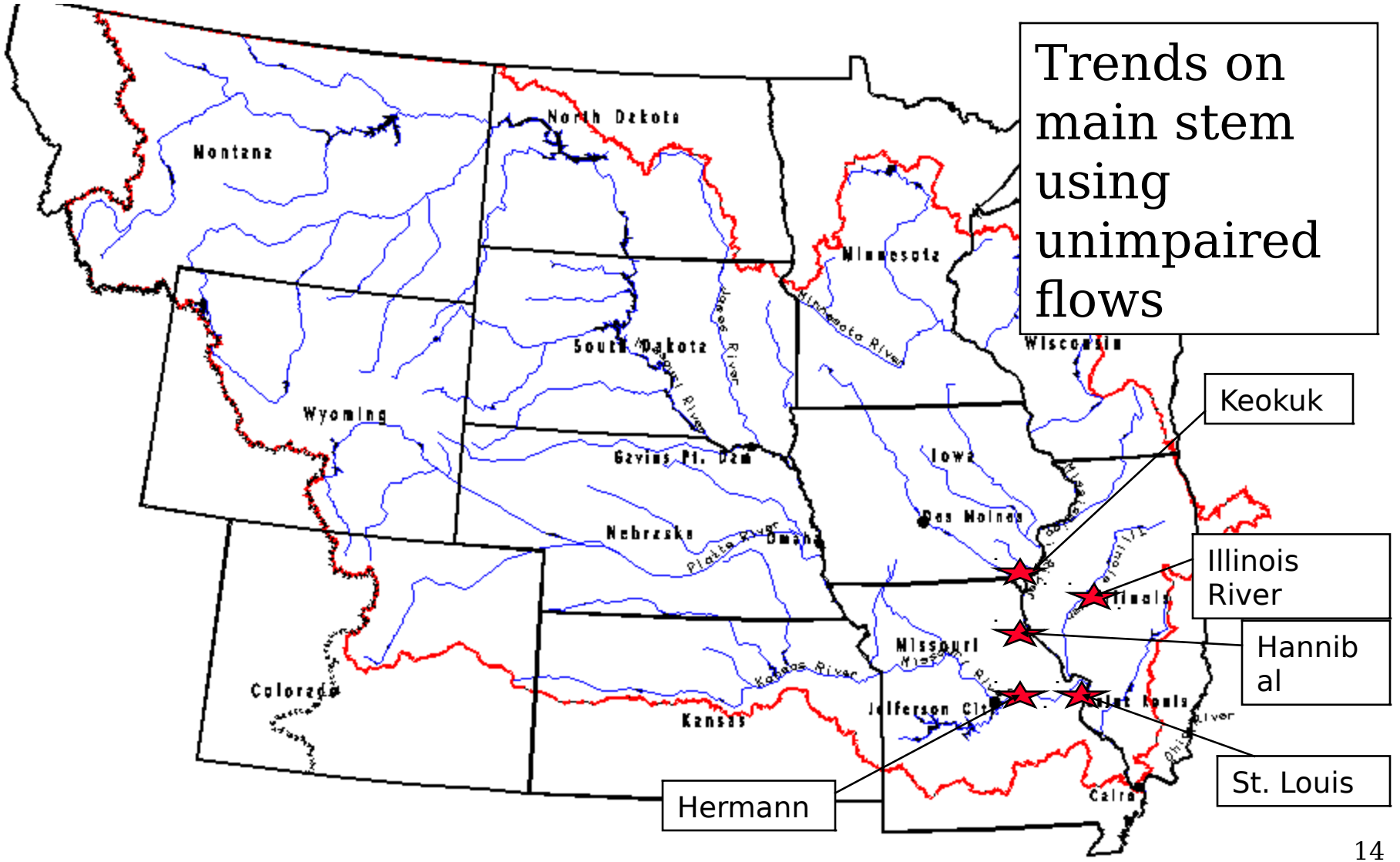


Annual Average Flows

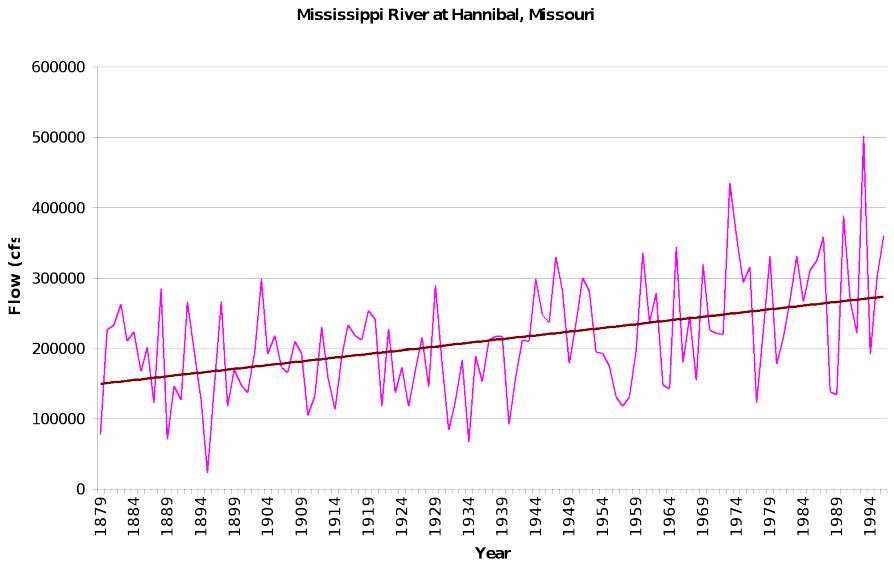


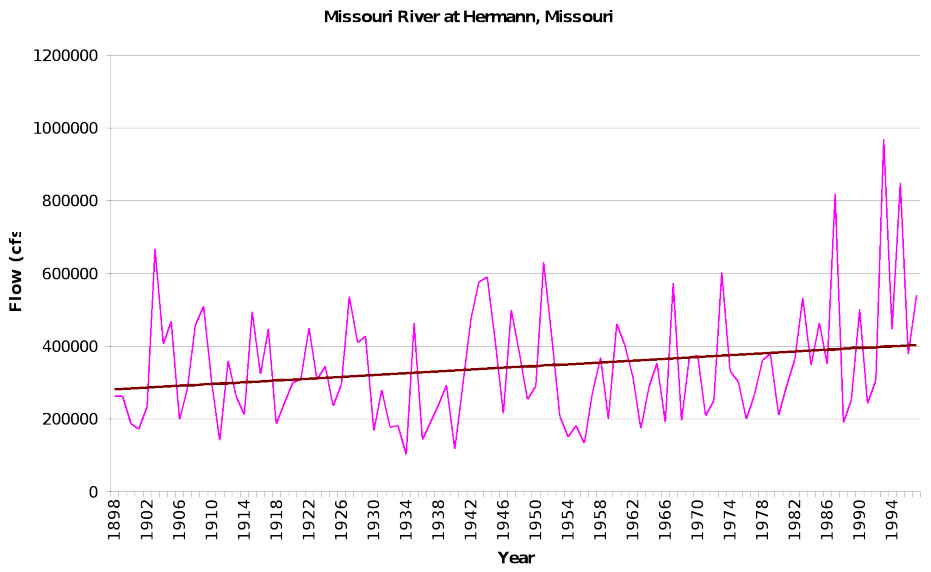
1-Day Low Flows

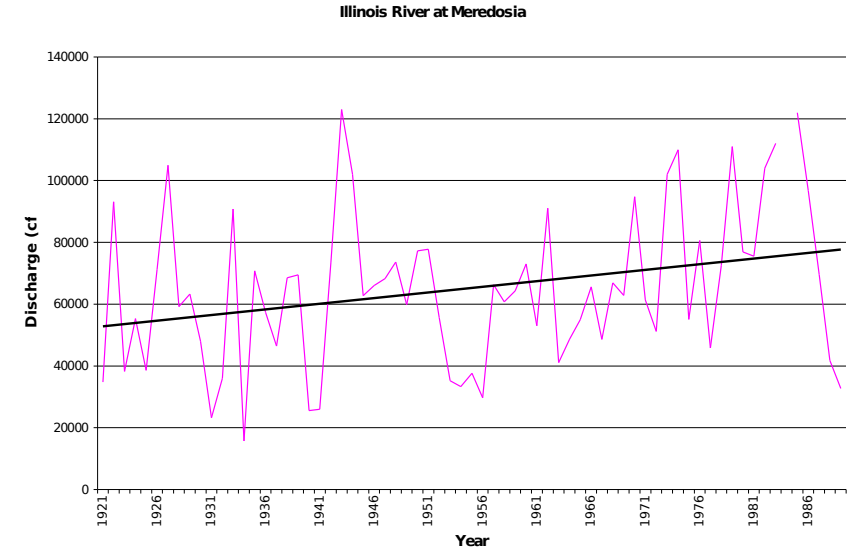
Significant Flood Trends

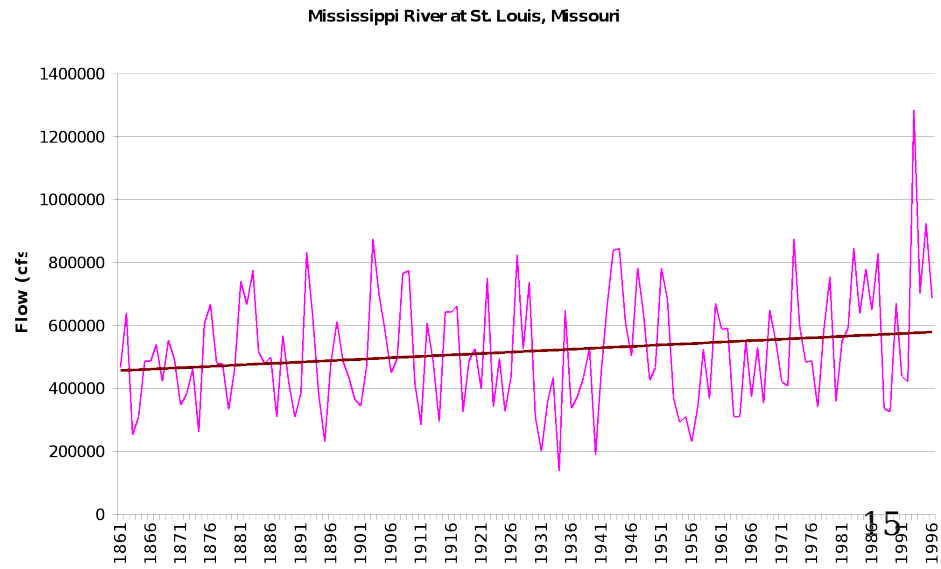


Trends in Annual Flood



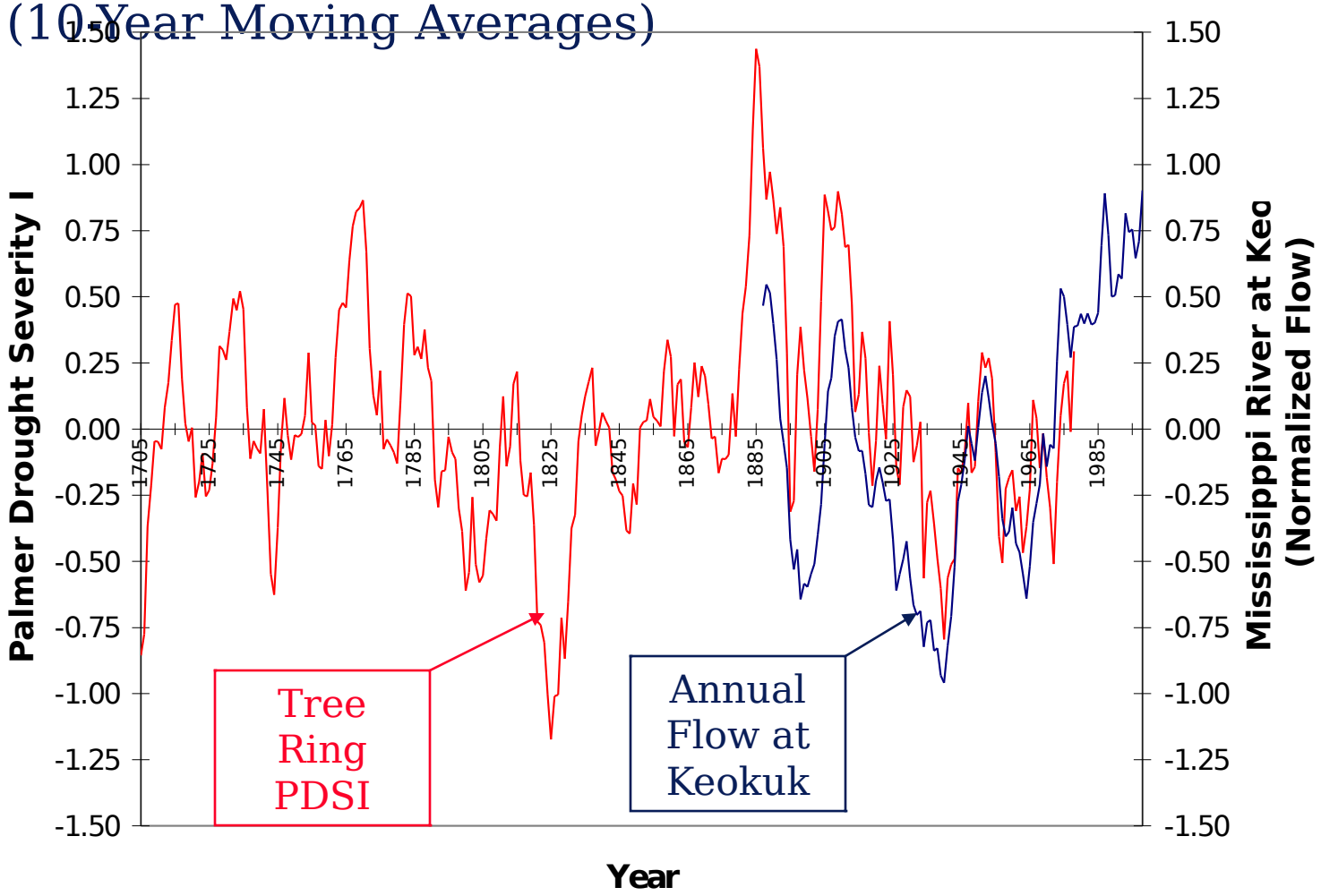






Paleoclimate

Comparison of Palmer Drought Severity Index Based on Tree Rings and Annual Average Flow of Mississippi River at Keokuk, Iowa (10 Year Moving Averages)



Alternative Statistical Models (that do not assume “stationarity”)

Alternative Models -1

- Incorporate trend into statistical model
  - Trend analysis depends on the period of time used in the analysis.
  - Requires a subjective evaluation of when the trend begins or ends.
  - Uncertain how to extrapolate the trend beyond the period of record.

Alternative Models – 2

- Employ selected subset of historical years to represent flood frequency distribution. (Use more recent period in place of the entire period of record).
  - If a short period of record is used, the results will lack precision.
  - Problematic to select representative subset of record.
  - Although it may be possible to determine “climate regime” for past periods of time, currently unable to predict when regime will shift.

Alternative Models – 3

- Condition flood series on climate indices (flood record is derived from low-frequency climate variations and climate indices represent the underlying climatic conditions).
  - Lack skill in predicting decadal climatic fluctuations.
  - Can assume low frequency index persist over next year, but planning generally requires longer planning horizon.

Alternative Models – 4

- No longer assume that the random variables are independent over time (pattern of episodic wet and dry periods that persist over several years).
  - Resulting variation in flood risk is unlikely to affect flood risk management.
  - Larger standard errors of mean and 100-year flood estimators than a model assuming independence.

Conclusions: Alternative Models

- Flood sequences affected by trends and interdecadal climate variability may be described as realizations of stationary persistent processes.
- Stationary time series allow risk to vary over time but preserve the assumption that hydrology is stationary in the long run.

Recommendations

- There is not enough compelling evidence to deviate from application of log-Pearson III distribution estimated by application of the method of moments to log flows.
- Currently no viable alternative in flood frequency analysis to using the assumption that flood flows are independent and identically distributed random variables.

Results

Comparison of 1% Chance Floods – Missouri River

Location	1962 Study	2003 Study	Difference
St. Joseph, MO	815.1	819.4	4.3
USGS Gage	*270,000 cfs*	*261,000 cfs*	
Kansas City, MO	748.5	749.5	1.0
USGS Gage	*425,000 cfs*	*401,000 cfs*	
Hermann, MO	518.4	518.6	0.2

Comparison of 1% Chance Floods – Mississippi River

Location	1979 Study	2003 Study	Difference
Keokuk, IA	500.8	501	0.2
USGS Gage	*351,000 cfs*	*366,000 cfs*	
Hannibal, MO	475.3	477.1	1.8
	374,000 cfs	*440,000 cfs*	
St. Louis, MO	427	426	-1

Data Quality Act Petition

Data Quality Act Petition

- Act requires Federal agencies to "issue guidelines ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information)" and allow "affected persons to seek and obtain correction of information."
- Submitted by Missouri Coalition for the Environment Foundation

Data Quality Act Petition

- “The flow frequency study relies on a key assumption that flooding has been stationary over the period of record, an assumption that lacks factual support.”
- “The existence of a trend of increasing flooding on the Midwest’s large rivers is also supported by a growing body of scientific literature, but the Corps almost completely ignored such literature when conducting the flow frequency study.”

Data Quality Act Petition

- “Report singles out two papers, Wolock and McCabe (1999) and Lins and Slack (1999) and uses these references to conclude that both studies of past flood trends and Global Climate Model (GCM) simulations of future changes in flood occurrence yield ambiguous and uncertain results.”

Conclusion

Conclusion

- Under conditions of climate change and variability, the uncertainty in the estimate of the 1% flood increases.
- Uncertainty in flood risk estimates should be communicated to floodplain communities and local sponsors of flood control projects.
- National Flood Insurance Program delineation of Special Flood Hazard Areas as 1% floodplain appears arbitrary.

Conclusion

- No uniform agreement on how to model non-stationarity.
- Flood frequency analysis with climate change could become more subjective and “political.”
- Federal agencies should consider updating Bulletin 17-B with one topic being how to treat interdecadal climate variability in flood risk assessment.